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MATHEMATICS.—*A table of the circular functions to radian argument.* C. E. VAN ORSTRAND, U. S. Geological Survey.

With the exception of a few tables containing values of the circular sine and cosine to a small number of decimals, there appears to be no satisfactory table to radian argument of these most important and fundamental of mathematical functions. Not only is it frequently necessary to use the higher values in the usual laboratory computations, but they are also needed for the construction of tables of the requisite accuracy in which circular functions are involved in trigonometrical equations or appear in simple relations which are derivatives of other functions. Important examples of such cases are:

$$\sinh (x \pm iy) = \sinh x \cos y \pm i \cosh x \sin y$$
$$\cosh (x \pm iy) = \cosh x \cos y \pm i \sinh x \sin y$$
$$gd^{-1}(x) = \int \sec x \, dx.$$

Instances of this kind arise from time to time as new applications of mathematical theory are gradually introduced into the various sciences.

The evaluation of the circular sine and cosine, and many other functions, is readily accomplished by repeated applications of Taylor's series. As a means of forming a basis for the application of the series in the present instance, 16 values of sin x and cos x between the limits 0.0 and 1.6 were computed roughly to 20 places of decimals by direct substitution in the respective

series. This computation is not a difficult task for the reason that tables of the factorials[1] have been published, and a table of the successive powers from 2 to 20 of the first 20 natural numbers may be readily formed and checked by comparing the 20th difference with $\lfloor 20$. The computation of terms of the form $x^n \div \lfloor n$ is then easily made and checked by differences. The summation of these terms need not be checked independently for the 10th interpolation must agree with the value obtained by direct substitution in the series.

If the interpolation formulas are written in the forms,

$$\sin(x + \Delta x) = \sin x + \frac{\Delta x}{\lfloor 1} \cos x - \frac{(\Delta x)^2}{\lfloor 2} \sin x - \frac{(\Delta x)^3}{\lfloor 3} \cos x + \ldots,$$

$$\cos(x + \Delta x) = \cos x - \frac{\Delta x}{\lfloor 1} \sin x - \frac{(\Delta x)^2}{\lfloor 2} \cos x + \frac{(\Delta x)^3}{\lfloor 3} \sin x + \ldots,$$

it will be noted that the two series together contain terms of the forms $(\Delta x)^n \sin x \div \lfloor n$ and $(\Delta x)^n \cos x \div \lfloor n$ where n assumes successive values of the natural numbers beginning with unity. We thus have two series of terms,

$$\frac{1}{\lfloor 2} \sin x, \quad \frac{1}{\lfloor 3} \sin x, \quad \ldots\ldots \quad \frac{1}{\lfloor n} \sin x,$$

$$\frac{1}{\lfloor 2} \cos x \quad \frac{1}{\lfloor 3} \cos x, \quad \ldots\ldots \quad \frac{1}{\lfloor n} \cos x,$$

which may be evaluated by dividing the sine or cosine, as the case may be, first by 2, this quotient by 3, the last by 4, and so on, thus avoiding the use of one large factor. The only effect of the factor $(\Delta x)^n$ is to shift the decimal point, and this may be determined once for all. The following details illustrate the method:

[1] J. W. L. Glaisher, Tables of the exponential function. Camb. Phil. Soc., Trans. 13: 246–247. 1883.

x	$\sin x$	$\cos x$
0.380	$\sin x = 0.37092\ 04694\ 12983$	$\cos x = 0.92866\ 46355\ 76510$
	$c\ \ 0.00092\ 86646\ 35577$	$3s\ \ 0.00000\ 00000\ 61820$
	$4s\ \ 0.00000\ 00000\ 00015$	$4c\ \ 0.00000\ 00000\ 00039$
	$\Sigma\ \ 0.37184\ 91340\ 48575$	$\Sigma\ \ 0.92866\ 46356\ 38369$
	$-2s\ \ 0.00000\ 01854\ 60235$	$-s\ \ 0.00037\ 09204\ 69413$
	$-3c\ \ 0.00000\ 00001\ 54777$	$-2c\ \ 0.00000\ 04643\ 32318$
	$-\Sigma\ \ 0.00000\ 01856\ 15012$	$-\Sigma\ \ 0.00037\ 13848\ 01731$
0.381	$\sin x = 0.37184\ 89484\ 33563$	$\cos x = 0.92829\ 32508\ 36638$

In the preceding notation, ns is used to represent $(\Delta x)^n \sin x \div \lfloor n$ and similarly nc represent $(\Delta x)^n \cos x \div \lfloor n$. The constant quantity Δx is here equal to 0.001.

The above method has been used in the preparation of a table consisting of 1600 values of $\sin x$ and $\cos x$ between the limits 0.000 and 1.600 with an accuracy of about 8 or 10 units in the 20th place of decimals. This table, a portion of which appears in the present paper, is to be published in full during the coming year. Further interpolations are being made for the purpose of obtaining a complete 10-place table which will also include values of $\tan x$ and $\cot x$ to the same degree of accuracy. All of the computations have been made by Messrs. William J. Ahern and Alfred G. Seiler, graduates of the McKinley Manual Training School of Washington, D. C.

The tabular error of the values in the following table is less than 5 units in the 16th place of decimals.

TABLE OF CIRCULAR FUNCTIONS TO RADIAN ARGUMENT

x	sine x	cosine x
0.00	0.00000 00000 00000	1.00000 00000 00000
0.01	0.00999 98333 34167	0.99995 00004 16665
0.02	0.01999 86666 93333	0.99980 00066 66578
0.03	0.02999 55002 02496	0.99955 00337 48988
0.04	0.03998 93341 86634	0.99920 01066 60978
0.05	0.04997 91692 70678	0.99875 02603 94966
0.06	0.05996 40064 79445	0.99820 05399 35204
0.07	0.06994 28473 37533	0.99755 10002 53280
0.08	0.07991 46939 69173	0.99680 17063 02619
0.09	0.08987 85491 98011	0.99595 27330 11994
0.10	0.09983 34166 46828	0.99500 41652 78026
0.11	0.10977 83008 37175	0.99395 60979 56697
0.12	0.11971 22072 88919	0.99280 86358 53866
0.13	0.12963 41426 19695	0.99156 18937 14788
0.14	0.13954 31146 44236	0.99021 59962 12637
0.15	0.14943 81324 73599	0.98877 10779 36042
0.16	0.15931 82066 14246	0.98722 72833 75627
0.17	0.16918 23490 66996	0.98558 47669 09561
0.18	0.17902 95734 25824	0.98384 36927 88121
0.19	0.18885 88949 76501	0.98200 42351 17270
0.20	0.19866 93307 95061	0.98006 65778 41242
0.21	0.20845 98998 46100	0.97803 09147 24148
0.22	0.21822 96230 80869	0.97589 74493 30605
0.23	0.22797 75235 35188	0.97366 63950 05375
0.24	0.23770 26264 27135	0.97133 79748 52030
0.25	0.24740 39592 54523	0.96891 24217 10645
0.26	0.25708 05518 92155	0.96638 99781 34513
0.27	0.26673 14366 88831	0.96377 08963 65891
0.28	0.27635 56485 64114	0.96105 54383 10771
0.29	0.28595 22251 04836	0.95824 38755 12697
0.30	0.29552 02066 61340	0.95533 64891 25606
0.31	0.30505 86364 43444	0.95233 35698 85713
0.32	0.31456 65606 16118	0.94923 54180 82441
0.33	0.32404 30283 94868	0.94604 23435 28387
0.34	0.33348 70921 40814	0.94275 46655 28346
0.35	0.34289 78074 55451	0.93937 27128 47379
0.36	0.35227 42332 75090	0.93589 68236 77935
0.37	0.36161 54319 64962	0.93232 73456 06034
0.38	0.37092 04694 12983	0.92866 46355 76510
0.39	0.38018 84151 23161	0.92490 90598 57313
0.40	0.38941 83423 08650	0.92106 09940 02885

TABLE OF CIRCULAR FUNCTIONS TO RADIAN ARGUMENT—Continued

x	sine x	cosine x
0.40	0.38941 83423 08650	0.92106 09940 02885
0.41	0.39860 93279 84423	0.91712 08228 16605
0.42	0.40776 04530 59570	0.91308 89403 12308
0.43	0.41687 08024 29211	0.90896 57496 74885
0.44	0.42593 94650 66000	0.90475 16632 19963
0.45	0.43496 55341 11230	0.90044 71023 52677
0.46	0.44394 81069 65520	0.89605 24975 25525
0.47	0.45288 62853 79068	0.89156 82881 95329
0.48	0.46177 91755 41483	0.88699 49227 79284
0.49	0.47062 58881 71158	0.88233 28586 10121
0.50	0.47942 55386 04203	0.87758 25618 90373
0.51	0.48817 72468 82907	0.87274 45076 45751
0.52	0.49688 01378 43737	0.86781 91796 77650
0.53	0.50553 33412 04847	0.86280 70705 14761
0.54	0.51413 59916 53113	0.85770 86813 63824
0.55	0.52268 72289 30659	0.85252 45220 59506
0.56	0.53118 61979 20883	0.84725 51110 13416
0.57	0.53963 20487 33969	0.84190 09751 62269
0.58	0.54802 39367 91874	0.83646 26499 15187
0.59	0.55636 10229 12784	0.83094 06791 00163
0.60	0.56464 24733 95035	0.82533 56149 09678
0.61	0.57286 74601 00481	0.81964 80178 45480
0.62	0.58103 51605 37305	0.81387 84566 62534
0.63	0.58914 47579 42270	0.80802 75083 12152
0.64	0.59719 54413 62392	0.80209 57578 84293
0.65	0.60518 64057 36040	0.79608 37985 49056
0.66	0.61311 68519 73434	0.78999 22314 97365
0.67	0.62098 59870 36560	0.78382 16658 80849
0.68	0.62879 30240 18469	0.77757 27187 50928
0.69	0.63653 71822 21968	0.77124 60149 97107
0.70	0.64421 76872 37691	0.76484 21872 84488
0.71	0.65183 37710 21537	0.75836 18759 90508
0.72	0.65938 46719 71473	0.75180 57291 40895
0.73	0.66686 96350 03698	0.74517 44023 44870
0.74	0.67428 79116 28145	0.73846 85587 29588
0.75	0.68163 87600 23334	0.73168 88688 73821
0.76	0.68892 14451 10551	0.72483 60107 40905
0.77	0.69613 52386 27357	0.71791 06696 10943
0.78	0.70327 94192 00410	0.71091 35380 12277
0.79	0.71035 32724 17608	0.70384 53156 52236
0.80	0.71735 60908 99523	0.69670 67093 47165

TABLE OF CIRCULAR FUNCTIONS TO RADIAN ARGUMENT—Continued

x	sine x	cosine x
0.80	0.71735 60908 99523	0.69670 67093 47165
0.81	0.72428 71743 70143	0.68949 84329 51747
0.82	0.73114 58297 26896	0.68222 12072 87614
0.83	0.73793 13711 09963	0.67487 57600 71267
0.84	0.74464 31199 70859	0.66746 28258 41308
0.85	0.75128 04051 40293	0.65998 31458 84982
0.86	0.75784 25628 95277	0.65243 74681 64052
0.87	0.76432 89370 25505	0.64482 65472 40001
0.88	0.77073 88788 98969	0.63715 11441 98580
0.89	0.77707 17475 26824	0.62941 20265 73697
0.90	0.78332 69096 27483	0.62160 99682 70664
0.91	0.78950 37396 89950	0.61374 57494 88812
0.92	0.79560 16200 36366	0.60582 01566 43463
0.93	0.80161 99408 83777	0.59783 39822 87298
0.94	0.80755 81004 05114	0.58978 80250 31098
0.95	0.81341 55047 89374	0.58168 30894 63883
0.96	0.81919 15683 00998	0.57351 99860 72457
0.97	0.82488 57133 38450	0.56529 95311 60354
0.98	0.83049 73704 91970	0.55702 25467 66217
0.99	0.83602 59786 00521	0.54868 98605 81588
1.00	0.84147 09848 07897	0.54030 23058 68140
1.01	0.84683 18446 18015	0.53186 07213 74355
1.02	0.85210 80219 49363	0.52336 59512 51650
1.03	0.85729 89891 88603	0.51481 88449 69955
1.04	0.86240 42272 43338	0.50622 02572 32778
1.05	0.86742 32255 94017	0.49757 10478 91727
1.06	0.87235 54823 44986	0.48887 20818 60528
1.07	0.87720 05042 74682	0.48012 42290 28534
1.08	0.88195 78068 84947	0.47132 83641 73740
1.09	0.88662 69144 49487	0.46248 53668 75301
1.10	0.89120 73600 61435	0.45359 61214 25577
1.11	0.89569 86856 80048	0.44466 15167 41707
1.12	0.90010 04421 76505	0.43568 24462 76712
1.13	0.90441 21893 78826	0.42665 98079 30157
1.14	0.90863 34961 15883	0.41759 45039 58358
1.15	0.91276 39402 60521	0.40848 74408 84157
1.16	0.91680 31087 71767	0.39933 95294 06273
1.17	0.92075 05977 36136	0.39015 16843 08230
1.18	0.92460 60124 08020	0.38092 48243 66882
1.19	0.92836 89672 49167	0.37165 98722 60533
1.20	0.93203 90859 67226	0.36235 77544 76674

TABLE OF CIRCULAR FUNCTIONS TO RADIAN ARGUMENT—Continued

x	sine x	cosine x
1.20	0.93203 90859 67226	0.36235 77544 76674
1.21	0.93561 60015 53386	0.35301 94012 19330
1.22	0.93909 93563 19068	0.34364 57463 16047
1.23	0.94248 88019 31698	0.33423 77271 24503
1.24	0.94578 39994 49539	0.32479 62844 38776
1.25	0.94898 46193 55586	0.31532 23623 95269
1.26	0.95209 03415 90516	0.30581 69083 78289
1.27	0.95510 08555 84692	0.29628 08729 25319
1.28	0.95801 58602 89225	0.28671 52096 31956
1.29	0.96083 50642 06073	0.27712 08750 56558
1.30	0.96355 81854 17193	0.26749 88286 24587
1.31	0.96618 49516 12734	0.25785 00325 32670
1.32	0.96871 51001 18265	0.24817 54516 52373
1.33	0.97114 83779 21045	0.23847 60534 33723
1.34	0.97348 45416 95319	0.22875 28078 08459
1.35	0.97572 33578 26659	0.21900 66870 93042
1.36	0.97786 46024 35316	0.20923 86658 91419
1.37	0.97990 80613 98614	0.19944 97209 97573
1.38	0.98185 35303 72360	0.18964 08312 97834
1.39	0.98370 08148 11277	0.17981 29776 72999
1.40	0.98544 97299 88460	0.16996 71429 00241
1.41	0.98710 01010 13850	0.16010 43115 54831
1.42	0.98865 17628 51720	0.15022 54699 11686
1.43	0.99010 45603 37178	0.14033 16058 46737
1.44	0.99145 83481 91686	0.13042 37087 38145
1.45	0.99271 29910 37588	0.12050 27693 67367
1.46	0.99386 83634 11645	0.11056 97798 20070
1.47	0.99492 43497 77581	0.10062 57333 86932
1.48	0.99588 08445 37640	0.09067 16244 64310
1.49	0.99673 77520 43143	0.08070 84484 54801
1.50	0.99749 49866 04054	0.07073 72016 67703
1.51	0.99815 24724 97548	0.06075 88812 19386
1.52	0.99871 01439 75583	0.05077 44849 33579
1.53	0.99916 79452 71476	0.04078 50112 41591
1.54	0.99952 58306 05479	0.03079 14590 82466
1.55	0.99978 37641 89357	+0.02079 48278 03092
1.56	0.99994 17202 29966	+0.01079 61170 58267
1.57	0.99999 96829 31835	+0.00079 63267 10733
1.58	0.99995 76464 98740	−0.00920 35432 68808
1.59	0.99981 56151 34291	−0.01920 24929 01693
1.60	0.99957 36030 41505	−0.02919 95223 01289

CHEMISTRY.—*Benzoic acid as an acidimetric standard.* GEORGE W. MOREY. Communicated by W. F. Hillebrand. To appear in the Bulletin of the Bureau of Standards.

The study of the suitability of benzoic acid as a primary standard in acidimetry and alkalimetry was suggested by experience gained in the purification of benzoic acid to be used as a calorimetric standard. During that work it was found that benzoic acid could be titrated with standard alkali to a high degree of accuracy and that this titration afforded the most rapid and accurate method of comparing the purity of various samples. Since pure benzoic acid has been furnished for some time by the Bureau of Standards as a calorimetric standard, it would of course be advantageous to use it also for a standard in acidimetry if found suitable.

Wagner,[1] in a report presented to the Fifth International Congress of Applied Chemistry, in 1903, mentioned benzoic acid among a number of other possibilities for the purpose named; and Phelps and Weed[2] included it in a short study of the availability of several organic acids and acid anhydrides.

The method used in studying this problem was that of standardizing a hydrochloric acid solution by several well known and standard methods, and comparing the results so obtained with those obtained by standardizing the same hydrochloric acid against benzoic acid. The methods chosen for the work were the distillation method of Hulett and Bonner, the gravimetric silver chloride method, comparison with a sulfuric acid solution standardized gravimetrically by the barium sulfate method, and comparison with the same sulfuric acid standardized volumetrically by the sodium oxalate method. All the materials used were prepared with the greatest care, and were carefully protected from the carbon dioxide of the air by suitable guard-tubes. Great care was taken to prepare and keep all solutions free from carbon dioxide, and each solution was tested from time to time for the presence of carbonate. All operations were con-

[1] Proc. Fifth Internat. Cong. Applied Chemistry, Berlin, 1: 323. 1903.
[2] Am. Jour. Sci. 26: 141. 1908.

ducted so to be as free from error as possible. Weight burettes were used for all titrations, which were made in a 300-cc. flask thru which passed a stream of air free from carbon dioxide. A one-per cent solution of phenolphthalein was used as indicator in all the titrations.

Direct standardizations of hydrochloric acid. The hydrochloric acid was first standardized in its preparation, having been prepared by the method of Hulett and Bonner,[3] which is based on the constancy of composition, at a definite atmospheric pressure, of the constant boiling mixture formed by hydrochloric acid and water. From the data given by Hulett and Bonner, the resulting solution was calculated to contain 0.0036396 gram HCl per gram solution, corresponding to a 0.1N factor of 0.9980.

The next standardization was by the silver chloride method with a 50-gram sample. The hydrochloric acid in the filtrate and washings was determined with the nephelometer and the amount found added to that calculated from the weight of silver chloride. Four concordant determinations by this method gave the value 0.0036611 gram HCl per gram solution, corresponding to a 0.1N factor of 0.9984.

The hydrochloric acid was standardized from the sulfuric acid by comparing the two solutions thru a solution of sodium hydroxide. The mean of six determinations of the ratio HCl: NaOH was 1.0464; of four determinations of the ratio H_2SO_4, 0.8454; the ratio H_2Cl: H_2SO_4 was therefore 1.2378. For the gravimetric standardization of the sulfuric acid a 50-gram sample was taken. After igniting and weighing in the usual manner the precipitates were tested for occluded barium chloride by the method of Hulett and Duschak,[4] but the amount found was always less than 0.1 milligram, a negligible quantity. The 0.1N factor for the HCl calculated from these determinations was 0.9984.

The standardization by means of sodium oxalate was made after a series of experiments made to compare various samples of sodium oxalate. While concordant results were obtained by strict adherence to a certain procedure in the transformation

[3] Hulett and Bonner: Jour. Am. Chem. Soc., 31: 390–393. 1909.
[4] Zeits. anorg. Chem., 40: 196. 1904.

of the oxalate to the carbonate, it was found that slight variations in the rate or manner of heating might produce very discordant results. The 0.1N factor calculated from the determinations with sodium oxalate was 0.9982.

Standardization of hydrochloric acid by benzoic acid. Because of the bulkiness of the sublimed benzoic acid, it was found convenient to fuse or compress it before weighing. Fusion has the advantage of diminishing the possibility of large surface effects. A platinum dish was filled with the sublimed benzoic acid and the covered dish placed in an oven heated to about 140°. When melted, the liquid was poured into a test tube, and after solidifying the stick so obtained was broken into pieces of convenient size and preserved in a glass stoppered bottle. Samples so prepared can be kept indefinitely and used without preliminary drying.

About a gram of this material was weighed and placed in a 300-cc. flask which had been swept free from carbon dioxide; 20 cc. of alcohol were added, the flask was stoppered and let stand until the sample had dissolved. Three drops of a 1 per cent solution of phenolphthalein were then added and the solution titrated directly with 0.1N alkali, a current of air free from carbon dioxide bubbling through the solution until the titration was completed. The end point chosen was that of a 7 per cent transformation of the indicator added, that being the end point which should give the best results.[5] The effect of the alcohol on the end point was determined in a blank experiment and the titrations corrected by this amount. This blank ranged from 0.06 to 0.08 cc.

In the first series of experiments a solution of barium hydroxide was used, this being the most convenient alkali to use when exclusion of carbon dioxide is necessary. The mean of four concordant determinations of the ratio HCl: $Ba(OH)_2$ was 1.3790. The mean of fifteen determinations, whose maximum difference was 1 part in 1600, gave the value 0.9984 for the 0.1N factor of the HCl. In a second series of experiments the

[5] Noyes: Jour. Am. Chem. Soc., 32: 857. 1910.

sodium hydroxide solution used in comparing the hydrochloric and sulfuric acids was used, for which the ratio HCl:NaOH was 1.0464. The mean of four concordant determinations was 0.9981.

Summary and conclusion. The results of the foregoing standardizations are summarized in the following table:

SUMMARY OF STANDARDIZATIONS

Method	0.1 N *factor for* HCl
Direct by Hulett and Bonner	0.9980
Direct by AgCl	0.9984
H_2SO_4–$BaSO_4$–NaOH–HCl	0.9984
H_2SO_4–$Na_2C_2O_4$–NaOH–HCl	0.9982
$C_6H_5CO_2H$–Ba $(OH)_2$–HCl	0.9984
$C_6H_5CO_2H$–NaOH–HCl	0.9981

The close agreement of these results proves the accuracy of the benzoic acid method. Moreover, benzoic acid has many advantages. Its high molecular weight permits the use of large samples, thus reducing the error of weighing; its stability and lack of hydroscopicity make it very convenient; and the method is rapid, since a single weighing and a titration are all the operations involved. These considerations, combined with the ease of obtaining it in a high state of purity, make benzoic acid an excellent material to use as a standard in acidimetry and alkalimetry.

ZOÖLOGY.—*The homologies of the so-called anal, and other plates in the pentacrinoid larvæ of the free crinoids.* AUSTIN HOBART CLARK, National Museum.

In the course of my studies upon the recent crinoids I have been able to examine many hundreds of pentacrinoid larvæ belonging to numerous species distributed in several families, and many points hitherto involved in obscurity have been made clear.

Unfortunately all of the work previously done upon the developing crinoid has been based upon one or other of the species of the genus *Antedon*, one of the most specialized of the genera in the group to which it belongs, and hence one of the least satisfactory for purposes of phylogenetic investigation.

In *Antedon* the so-called anal plate is formed at about the period of development of the IBr_2, between the two posterior radials; but it is noticeable that while the radial to the left of it is of normal shape, that to the right has its left side more or less cut away for its reception. When the anal is lifted out from the circlet of radials just previous to its resorption it is noticeable that it keeps to the right of the posterior interradial area, remaining more or less in contact with the right hand radial and first primibrach, instead of being drawn directly upward as would be expected; also the right radial is asymmetrical, more convex on the right side than on the left (adjoining the anal) though after the withdrawal of the anal this asymmetry quickly disappears.

The general tendency of the anal plate of the young *Antedon* to keep to the right of the posterior interradial area, though very strongly marked, does not appear ever to have attracted attention; but it is nevertheless a fact of the very highest importance.

In more primitive species, in which the five infrabasals are large and equal in size, the anal appears to be formed before any of the radials, occupying a position in the rhombic area between the corners of the basals and orals. Soon afterward the radial appears, just to the right of and in line with it, between the basal and oral of that side and to the right of the vertical line dividing the basals and the orals. The radial grows much faster than the anal, which it gradually surrounds so that the latter comes to lie in a deep concavity in the side of the radial to the right of it and to the right of the posterior interradius, well to the right of the midline of the posterior basal. Later this right hand radial extends itself beneath the anal and the concavity becomes straightened out and disappears, the anal concurrently being shoved diagonally forward (toward the left) and disappearing by resorption.

In certain fossils groups there may be traced a progessive variation in the position of the radianal from a primitive position directly under the right posterior radial to an oblique position under the lower left hand corner of the radial, and finally to complete elimination. The position of the so-called anal in the larvæ of the more primitive comatulids, lying within a concavity in the lower left hand portion of the radial to the right of the posterior

interradius and its migration upward and toward the left leave no room for doubt that the so-called anal of the pentracrinoid larvæ is nothing more nor less than the radianal of the fossil forms.

Since the radianal is represented in the larvæ of the comatulids we should expect also to find a representative of the plate known as anal *x*. Now in forms in which the radianal is present anal *x* lies directly over the posterior basal, always to the left of the radianal and always maintaining a closer relation with the radial to the left of the posterior interradial area than with that to the right, with which the radianal is associated. Whereas the radianal is always a single plate, anal *x* commonly forms the base of a short series of more or less similar plates.

In the so-called *Thaumatocrinus renovatus* the posterior interradial area is occupied by a large interradial plate bearing upon its distal edge a conical process composed of a series of calcareous rings; this process lies to the left of the base of the anal tube, and therefore presumably to the left of the recently vanished radianal.

The free arms of the crinoids are composed of an extension of the boundary between the primarily skeleton forming dorsal surface and the perisomic ventral surface. Although phylogenetically very complicated, ontogenetically they arise as a linear (or double) series of ossicles, each new ossicle being added at the extremity of the series; none of the phylogenetic processes by which they originated are recapitulated. In short a crinoid arm in all the forms we know is nothing but a double or single series of ossicles supporting an extension of the ventral perisome—a series of simple braces of long forgotten origin.

The fixity of the crinoid arm as an individual structure entirely distinct from the crinoid arm as a phylogenetic complex—the conception of the crinoid arm as a structure with an identity of its own and with an ontogenetically completely obliterated phylogenetic origin—must constantly be kept in mind; for when we are able to grasp this idea we see at once that *any* series of ossicles arising on the border between the dorsal skeleton forming and ventral perisomic surfaces, and being composed in equal parts of each, will assume the structure common to all the processes arising in the same region, and will take on from the beginning the struc-

ture of the crinoid arm, exactly as every process from the centrodorsal will become a cirrus and every one arising on the distal corner of a brachial will become a pinnule.

Thus while a plate if situated below the ventral edge of the perisomic surface may give rise to a simple series of more or less similar plates running up to the edge of the ventral surface, and possibly continued further along the anal tube, the same plate if situated just at the ventral surface will give rise to an arm or a group of arms exactly like those arising from the radials. The character of the ossicles following a plate is not determined so much by the character of the plate itself as by its position in reference to the boundary between the dorsal and ventral surfaces of the animal.

I have examined pentacrinoids in which both the radianal and anal *x* are present, the former dwindling, the latter increasing in size. They are situated side by side between the two posterior radials.

In some thirty six-rayed specimens which I have studied the supernumerary ray is in all cases but two inserted behind the left posterior; that is, between the two posterior radials, and receiving its ambulacra from the groove trunk to the left.

It is thus clear that in *Thaumatocrinus renovatus* we have a young comatulid just after the resorption of the radianal with anal *x* fully developed and bearing a rudimentary arm which eventually will increase in size and become indistinguishable from the other arms.

This establishes the identity of the supposed species. Since anal *x* has given rise to an additional arm it is only reasonable to suppose that all the other interradial plates, which are exactly like it, will do the same thing. There will therefore result a ten-rayed form with ten undivided arms from which IBr series will be absent. Such a condition characterizes the genus *Decametrocrinus*, one species of which, *D. abyssorum*, was the only other crinoid dredged with *Thaumatocrinus renovatus*, and *Decametrocrinus* and *Thaumatocrinus* have since been found similarly associated.

Anal x in the fossil forms may be reduplicated in the form of a series of interradials, one in each of the other interradial areas; and it therefore does not surprise us to see the same thing in the recent comatulids.

Sir Wyville Thomson notes that in one or two cases he observed about the time of the first appearance of the anal (radianal *mihi*) a series of five minute rounded plates developed interradially between the lower edges of the oral plates and the upper edges of the basals. These are strictly homologous with the interradials of the so-called *Thaumatocrinus*, and that in the posterior interradius is anal x.

In this connection it is most interesting to examine the figure published by Mr. Frank Springer (Journ. Geology, **14**: No. 6, 1906, pl. 5, fig. 9; explanation p. 493) to show the probable primitive structure of the anal interradius and adjacent parts of the calyx in the whole Flexibilia type, both fossil and recent. If we should carry backward to its probable inception the course indicated by the migration of the radianal plate in the young of the recent comatulids we should arrive at a calyx structure identical with that shown by Mr. Springer and deduced from the study of the fossil forms; with the possible trivial difference that we should be inclined to assume the reduplication of anal x in the shape of interradials in all the other interradial areas, though from the data acquired from the study of six-rayed forms it would seem that we would be justified in considering these four additional interradials as a later development.

Mr. Springer has shown (Journ. Geology, **14**: 496. 1906) that in the Flexibilia there is a very pronounced tendency shown by all the radial structures to turn toward the right; the radianal originates under the right posterior radial; from this position it migrates upward until it disappears, always to the right of the median line; if the arms have an asymmetrical distortion it is toward the right, never toward the left; the vertical series of plates arising from the anal x is affected by this tendency, which persists long after the radianal has disappeared.

In the comatulids the radianal follows the same course as in a succession of fossil genera; the anal tube is always to the right

of the median line of the posterior interradius; that the supplementary arm arising on the anal *x* of *Thaumatocrinus renovatus* does not turn to the left is to be interpreted purely as a secondary condition, the result of its origin on the edge of the disk and its free extension outward from the body. Were this series of ossicles following anal *x* in *Thaumatocrinus* incorporated in the perisome we cannot doubt but that it would have followed the anal tube in its migration to the right, and would therefore have come into complete correspondence with the conditions seen in the fossil Flexibilia.

In *Thaumatocrinus renovatus* the disk between the margin and the orals is completely enclosed by a pavement of small plates which later disappear, and the same is true in certain other forms. This heavy plating of the disk in the very young of species of which the adults have naked disks must be of very profound significance, and, when taken in connection with the occurrence of the radianal and anal *x*, and with various other features, strongly indicates that it is the transient vestige of the forerunner of the dome of the Camerata.

SUMMARY

1. The so-called anal in the pentacrinoid larvæ of the recent comatulids is in reality the radianal of the fossil forms.

2. Anal *x* is represented in the pentacrinoid larvæ of the comatulids by a posterior interradial which gives rise to an additional post-radial series, as in *Thaumatocrinus renovatus* and in six-rayed specimens of other species, or by a minute plate which is quickly resorbed; in the recent forms it is repeated in all the interradial areas.

3. *Thaumatocrinus renovatus* is merely the young of *Decametrocrinus abyssorum* (P. H. Carpenter).

4. The solid plating of the disk which appears in the young of certain forms concurrently with the disappearance of the orals, quickly to be resorbed, is the transient vestige of the condition which developed into the solid dome of the Camerata.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

METEOROLOGY.—*Free air data, sounding balloon ascensions at Indianapolis, Omaha, and Huron.* WM. R. BLAIR. Bulletin of the Mount Weather Observatory, **4**: 183–304. 1911.

Four series of sounding balloon ascensions, giving 79 good records, were made by the U. S. Weather Bureau at the above places during the years 1909, 1910 and 1911. One of these ascensions, the one made at Huron, S. Dak., Sept. 1, 1910, is the highest on record, 30,486 meters.

The data obtained from all these ascensions, temperature, pressure, humidity, height, wind velocity and wind direction, are given in detail in a number of tables and diagrams and the final summary and discussion include 59 additional ascensions made at St. Louis, Mo., and at Pittsfield, Mass by the Blue Hill Meteroological Observatory.

Among the conclusions reached are:

a. Rapid changes of condition with altitude seem to occur at elevations of about 1.2, 3.5, 10.5, 15.5, and 28.0 kilometers. That is to say, at the upper limit of diurnal convection, upper level of the lower condensation layer, average level of the upper condensation layer, upper limit of condensation, and a much higher level, respectively.

b. The first and second of the above levels and the third over rising air pressure at the earth's surface are at greater elevations in summer than in winter; the fourth level is highest in spring and lowest in autumn.

c. The change in temperature with altitude is increased, with a rising barometer, up to the first level; decreased from the first to the second, and at higher levels not much affected.

d. At the third level the temperature decreases slowly with altitude, at the fourth it increases and at the fifth it again decreases.

e. Air temperatures are lower above the third level and higher below it with a falling than they are with a rising barometer.

f. The wind velocity seems to decrease above the fourth level; its mean direction is west-northwest. In the lower levels, however, the wind distribution, as already known, is largely controlled by the distribution of surface pressure.

In explanation of the observed phenomena it is suggested that the peculiarities of temperature distribution, including the "latitude effect" and the upper inversion of temperature, may be due to the influence of convection on the distribution of the constituent gases, vapors and dust of the atmosphere. W. R. B.

METEOROLOGY.—*Free air data at Mount Weather for July, August, and September*, 1911. Wm. R. Blair. Bulletin of the Mount Weather Observatory, **4**: 342–395. 1911.

During this period 112 kite and captive balloon records were obtained of pressure, temperature, relative humidity, wind direction and wind velocity, the details of which are given in tables and charts. Besides this the surface temperatures of the mountain kite station and of two adjacent valley stations are given in diagram.

Two series of 8 ascensions each were made, August 16–17, and September 12–13, for studying the diurnal changes that take place in the various elements observed. Clear weather was chosen for both series and observations were obtained at all altitudes up to 3 kilometers above sea level. The results show that on these dates the 1.5 kilometer level was one of transition at which the hourly departures of the temperature from the mean for the day were least; that below this elevation the diurnal maximum temperature occurred at about 3 to 5 p.m., and the minimum at 1 to 2 p.m.

In the discussion it is pointed out that the diurnal convection currents probably rose to the 1.5 kilometer level, or a little higher, on the days in which the observations were made, and it is therefore suggested that the contributions to and the distribution of the constituents of the lower atmosphere by these currents probably were responsible for the peculiar temperature distribution observed. W. R. B.

METEOROLOGY.—*The upper atmosphere*. W. J. Humphreys. Bulletin of the Mount Weather Observatory, **4**: 402–408. 1912.

This paper is a critical examination of our present knowledge of and inferences concerning the atmosphere above the level of the highest clouds. The conclusions reached are as follows:

Sources of information: (1) Records of sounding balloons, (2) Obser-

vations of meteors, (3) Observations of twilight phenomena, (4) Observations of auroras, (5) Observations of noctilucent clouds,

Chief facts of observation: (1) At and beyond 11 kilometers up to the greatest elevation yet reached, about 30 kilometers, the temperature is substantially constant at any given time and place, (2) The humidity of the upper atmosphere is vanishingly small, (3) The upper atmosphere consists in part of hydrogen and helium, (4) The atmosphere is sufficiently dense at an elevation of 150 kilometers to fire meteors, (5) The atmosphere at 70 kilometers elevation still scatters a perceptible amount of light.

Chief inferences: (1) The temperature of the upper atmosphere is substantially constant with respect to elevation far beyond the limits yet reached by sounding balloons, (2) The upper atmosphere is practically free from vertical convection, (3) The volume percentages of the gases at the beginning of the isothermal region are the same as those of dry air at the surface of the earth, (4) Above this level the lighter gases gain in percentage with increase of elevation, (5) Above 75 kilometers, mass-density and light-intensity soon decrease very slowly with increase of elevation, while below this level they soon increase rapidly with decrease of elevation, (6) Above 75 to 80 kilometers dust falls comparatively rapidly, while below this level it settles more and more slowly, (7) There is no level at which either mass-density or light-intensity changes in any sense abruptly with changes of elevation.

W. J. H.

METEOROLOGY.—*Echelon clouds.* W. J. HUMPHREYS. Bulletin of the Mount Weather Observatory, **4**: 409–411. 1912.

Under certain conditions a great many small cumulus clouds appear with flat bases, and all at substantially the same elevation. When viewed from a point to one side and at a lower level such a cloud formation appears in perspective like a series of inverted terraces, or like an extensive inverted flight of steps.

The meteorological meanings of the cloud phenomena just described are, among others: (*a*) That the cloud bases are all on about the same level, (*b*) That the vertical distribution of water vapor is essentially the same over all the region covered by the clouds in question, (*c*) That the change of temperature with altitude above any given place in this region is substantially the same as it is above any other, (*d*) That the amount of humidity is rather large, (*e*) That vertical convection is occurring in many separate places, but nowhere violently. W. J. H.

PHYSICS.—*The spectroscopic determination of aqueous vapor.* F. E. Fowle. Astrophysical Journal, April 1912, p. 149.

By laboratory experiments on the transmissibility of radiation through long columns of air containing known amounts of water vapor the dependence of transmission on the water-vapor content has been determined for the intra-red bands Φ and Ψ. The direct determinations cover quantities of water vapor up to a depth of 0.5 centimeters of precipitable water. Beyond this the determinations have been extended by aid of solar observations made on Mount Wilson. This extension does not require assumptions as to the actual quantities of water vapor in the solar beam, but only as to the relative quantities as fixed by the length of path of the beam. As the purity of the spectrum enters into the results it has been necessary to determine the dependence of transmission on water vapor for different values of combined slit- and bolometer-width. While the experiments have been made only at atmospheric pressure, a computation is given which shows that the results are probably applicable with slight correction to the actual pressures at which water vapor occurs in the atmosphere. Accordingly, a method has been established by means of which the total quantity of water vapor between the observer and the sun may be easily determined by spectro-bolometric observations. It is proposed in subsequent papers to give applications of the method. F. E. F.

AGRICULTURAL PHYSICS.—*The effect of soluble salts on the physical properties of soils.* R. O. E. Davis. Bulletin 82, Bureau of Soils.

The addition of small amounts of soluble salts affect the physical properties and therefore the structure of the soil. No predictions can be made regarding the specific direction or the amount of the action of salts on particular soils. The effect of salts is more pronounced in a soil containing a large percentage of fine soil particles and this leads to the conclusion that colloid-like clay particles are affected most by soluble salts and in turn effect most the structure of the soil. The actual nature of the condition produced in the smallest soil particles is not known beyond the fact that flocculation and deflocculation may be produced.

M. X. Sullivan.

AGRICULTURAL CHEMISTRY.—*The distribution of organic constituents in soils.* Oswald Schreiner and E. C. Lathrop. Journal Franklin Institute, August. 1911.

Twenty-six samples of soils from eleven different states were examined for known organic soil constituents which had previously been isolated

from one soil or another. From the data obtained it would appear that pentosans, pentose sugars, histidine, cytosine, xanthine, hypoxanthine and dihydroxystearic acid are rather common soil constituents and are likely to be encountered in soils everywhere. Although agroceric acid, lignoceric acid, paraffinic acid, α-monohydroxystearic acid, as well as agrosterol, phytosterol, and hentriacontane were only found in one or two soils, no general statement covering their frequency or infrequency of occurrence is warranted. Arginine, a common cleavage product of protein, was found in only two soils and it is probably a soil constituent which persists in the soil only a short time. E. C. L.

AGRICULTURAL CHEMISTRY.—*Studies in organic soil nitrogen.* E. C. LATHROP and B. E. BROWN. Journal Industrial Engineering Chemistry, **3**: 657-660. 1911.

The largest part of the N in the soil exists in complex organic forms, and this paper deals with an analytical attempt to determine in what combination this N exists. Five soils, Hagerstown loam, from the plats of the Pennsylvania State College Experiment Station, which had been under treatment since 1881 were examined. The soil was heated with HCl and in the acid solution total N, Ammonia N, mono and diamino acid N and "Humin" N were determined by the method of Hausmann as modified by Osborne and Harris. The NH_3 liberated and the amount of soluble organic nitrogenous compounds caused by heating the soil with water under pressure from 1 to 10 atmospheres was also studied. By the latter method it was shown that the organic N in the lime-treated plats was in different combination from that of the other plats. There was a wide variation in the amounts of mono and diamino acid N and there seemed to be no agreement between amino N and plat treatment. The ammonia and amino acid N will be directly available for plant use and, in these plats, these two together, form 40–60 per cent of the total N in the soils. The "Humin" N is not considered to be directly available and these soils would yield on decomposition 40–60 per cent of such compounds. Since these 5 soils are really the same soil under long continued treatment of different kinds, the work shows that different decomposition of the nitrogenous matter has taken place and probably will continue to take place under such different conditions imposed in the field. E. C. L.

AGRICULTURAL CHEMISTRY.—*A beneficial organic constituent of soils: Creatinine.* Bulletin 83, Bureau of Soils. Introduction: Importance of beneficial constituents. O. SCHREINER. I. The isolation of creatinine from soils. E. C. SHOREY. II. The origin of creatinine in soils. M. X. SULLIVAN. III. The effect of creatinine on growth and absorption. J. J. SKINNER.

In this bulletin, the presence in soils of a constituent decidedly beneficial to growing crops is emphasized. This soil constituent is creatinine, a nitrogenous compound. The first paper deals with the isolation, identification, and chemical properties of the compound. The relation of creatinine to other organic compounds is pointed out and observations are made regarding the possible connection between creatinine and other organic soil constituents. Creatinine is a frequently occurring and probably a normal constituent of soils in amounts comparable to the quantities of nitrates normally present. Like the nitrates, it is probably a fluctuating quantity. The presence of creatinine in stable manure and cowpea vines is also pointed out. In the second paper, the occurrence of creatinine in plants and cropped soil is shown. Of samples of the same soil, planted and unplanted, kept side by side in the greenhouse, the planted soil gave larger amounts of creatinine. Creatinine was also found in the water in which wheat seedlings had grown, and was demonstrated for the first time in plants, wheat seeds, wheat seedlings, and wheat bran, in seeds of rye, clover, and alfalfa, in mature cowpea vines, and in potatoes. In the third paper it is shown that creatinine and creatine have beneficial effects on plant growth. Plants grown in solution cultures containing only potash and phosphate have shown increased growth when creatinine or creatine is added. When large amounts of nitrates are present in the solution, creatinine and creatine produce no appreciable effect on the growth. In the presence of these compounds, the plants absorb less nitrate, while the absorption of potash and phosphate is normal. It appears that creatinine and creatine can replace the nitrate in solution cultures. M. X. SULLIVAN.

AGRICULTURAL CHEMISTRY.—*Organic compounds and fertilizer salts.* Bulletin Bureau of Soils 77. OSWALD SCHREINER and J. J. SKINNER.

The action of fertilizer salts in restraining the harmful influence of certain organic compounds was studied as well as the effect of the compounds on absorption. The effect of cumarin, vanillin and quinone was tested on wheat in soil and water cultures. The culture solutions

comprised all possible ratios of the three principal fertilizer elements, phosphate, nitrate, and potassium in 10 per cent stages. The various fertilizer salts acted differently in overcoming the respective harmful effects of the toxic compounds. The mainly phosphatic fertilizers were the most efficient in overcoming the cumarin effects; the mainly nitrogenous in overcoming the vanillin effects; the mainly potassic in overcoming the quinone effects.

Cumarin affected plants have characteristic stunted tops, broad distorted leaves; vanillin affected plants are less characteristic, but show decreased growth of tops and strongly inhibited root growth. Quinone affected plants are tall and slender with thin narrow leaves in strong contrast to the cumarin affected plants. The cumarin depressed potash and nitrate removal from the nutrient solution more than it did phosphate removal; the quinone on the other hand depressed phosphate and nitrate more than it did potash. The effect of vanillin was not determined in this regard. Dihydroxystearic acid which appears to act much as vanillin did, depressed phosphate and potash more than nitrate. The conclusion is drawn that different toxic substances produce definite effects in their action on plants and that the effects are modified differently by the different fertilizer salts. J. J. S.

AGRICULTURAL CHEMISTRY.—*Origin of creatinine in soils.* M. X. Sullivan. Science **35**: 390. 1912.

Of samples of the same soil planted and unplanted kept side by side in the greenhouse, the water and glycerine extracts of the planted soils gave larger amounts of creatinine by the creatinine zinc chloride method. It would seem that the increase in the amount of creatinine was connected in some way with plant growth. Creatinine was found in small amounts in the water in which wheat seeding had grown, in wheat seeds, wheat seedlings, wheat bran, rye, clover, alfalfa, cowpeas and potatoes. Besides the possible production of creatinine by microorganisms and the introduction into the soil in the animal excreta of stable manure, the creatinine of soils has its origin in vegetable matter. M. X. S.

AGRICULTURAL CHEMISTRY.—*The action of nucleic acid and its decomposition products on soils and plants.* O. Schreiner and J. J. Skinner. Science **35**: 390. 1912.

Nucleic acid as well as some of its decomposition products occur in soils and the effect of some of these compounds has been studied with

wheat seedlings. Mineral nutrient solutions with phosphate, potash, and nitrate in varying proportions were used, and to these were added 50 parts per million of the compound tested. The neutralized nucleic acid as well as its nitrogenous decomposition products, hypoxanthine and xanthine, had a beneficial action on the plants, promoting growth and decreasing the nitrate absorption. The plants appear to be able to utilize these compounds directly in their metabolism and require under these circumstances less nitrate for maximum growth.

M. X. SULLIVAN.

AGRICULTURAL CHEMISTRY.—*Nucleic acids in soils.* E. C. SHOREY. Science **35:** 390. 1912.

Nucleic acids have been obtained from soils by extraction with dilute sodium hydroxide, neutralizing and concentrating under reduced pressure, acidifying with acetic acid and addition of several volumes of alcohol as a light colored amorphous body which on hydrolysis gave pentose sugars, purine bases, pyrimidine compounds, levulinic acid and phosphoric acid. Xanthine and hypoxanthine were identified among the purine bases and cytosine among the pyramidine compounds.

M. X. SULLIVAN.

AGRICULTURAL CHEMISTRY.—*Examination of soils for organic constituents, especially dihydroxystearic acid.* O. SCHREINER and E. C. LATHROP, Bulletin 80, Bureau of Soils. Journal American Chemical Society **33:** 1412–17. 1911.

This investigation covers a partial survey of the nature of organic matter in the soils of the United States. Soils from eighteen different states, and of widely different origin, topography, texture, climate, drainage, and cropping, varying from soils of the highest productivity to soils incapable of producing profitable crops were examined for different soil constituents. In the soils, pentsans, pentose, sugar, histidine, cytosine, xanthine, hypoxanthine, and dihydroxystearic acid were frequently encountered. Arginine, agroceric acid, lignoceric acid α-monohydroxystearic acid, agrosterol, phytosterol, and hentriacontane were only ocassionally found. The frequent occurrence of dihydroxystearic acid is of special interest and significance because of its known harmful action on plants One-third of all the soils examined contained this compound, virgin soils as well as soils long under cultivation; soils continually cropped as well as soils under permanent sod; soils from the Atlantic coast, the Pacific coast and the Gulf states. It is likely to be

encountered in soil anywhere. Its formation or accumulation is doubtless due to local conditions which may obtain in any region. Of 25 good soils examined, only two contained dihydroxystearic acid, and they were of moderate productivity. Of 35 poor soils examined 51 per cent contained it. Of the soils which had a record for infertility, the dihydroxystearic acid was found in every case. It is either a direct or an indirect factor in low productivity, direct because of its harmful effects and indirect as arising and accumulating under poor soil conditions. The determination of this one constituent leads to a recognition of the kind of infertility in the soils examined and is, therefore, a readily recognized symptomatic factor of poor soil conditions. M. X. SULLIVAN.

FISHERIES.—*Fishes from Bering Sea and Kamchatka.* CHARLES HENRY GILBERT and CHARLES VICTOR BURKE. Bulletin of the Bureau of Fisheries, **30**: 31–96. 1910. 37 text fig. Issued May 6, 1912.

This paper, based upon collections by the United States Fisheries Steamer *Albatross* during her cruise in the northwest Pacific in the summer of 1906, "serves again to emphasize the bewildering richness of the northern Pacific in cottoid and liparid forms. Genera like *Triglops*, *Icelus*, *Artediellus*, and *Gymnocanthus*, which are represented in the north Atlantic by one, or at most two, species, contain in the northwestern Pacific numerous forms, some of which may be widely divergent. Such facts are usually accepted as conclusive evidence of the original home and the center of dispersal of the group thus richly represented."

"On the basis of the hasty reconnaissance which the *Albatross* was able to make in passing, no sharply defined faunal lines are indicated in the region here considered. In passing from the eastern end of the Aleutian chain westward to Attu and Agattu only minor changes seem to occur. There is no perceptible break between the Aleutians and the Commander Group. The best defined division appears to coincide with the deep channel which separates the Commander Islands from Kamchatka. This is indicated by the failure of certain species to cross this barrier, and by the presence on the two sides of incipient species—representative forms which have only slightly diverged, as though under the influence of prolonged isolation."

These collections were found to contain 121 species of fishes, of which 35 are described as new, 8 of the genera also being new.

ETHEL M. SMITH.

FISHERIES.—*Studies on the reproduction and artificial propagation of freshwater mussels.* GEORGE LEFEVRE and WINTERTON C. CURTIS. Bulletin U. S. Bureau of Fisheries, **30:** 105–202, pl. vi–xvii, 4 text fig. 1910.

The extended biological researches reported upon in this paper are the basis upon which the U. S. Bureau of Fisheries, through its station at Fairport, Iowa, is undertaking to propagate the commercially valuable species of pearl mussels in the interests of the pearl button manufacturing industry, which derives its raw materials from unionid shells found in waters of the Mississippi basin.

A large preliminary portion of the paper relates to the Unionidae from the historical biological standpoint, but their mode of reproduction, structure, and the development and parasitism of the larvae are naturally given chief and most detailed consideration and lead to an extended account of the experiments and observations made for the purpose of economic application of the facts. Messrs. Lefevre and Curtis confirm previous investigators in their findings as to breeding seasons of the Unionidae, the short and long periods of gravidity being generic characters; and they also find the two well-marked types of glochidia, those with hooks, which attach themselves chiefly to the fins of fishes, and those without hooks, which are found in the gill filaments. A third type, of ax-head shape, was also found in a few closely related species. One genus, *Strophitus*, was found to develop without a parasitic stage.

As it proves upon experiment that the species of fish most satisfactory as hosts for the larval mussels are the black basses and sunfishes so numerous in Mississippi waters and collected yearly by the U. S. Bureau of Fisheries in great quantities from the overflows, it was found comparatively easy to contrive means for wholesale infection of young fish before distributing them for the regular fish-cultural purposes, and the Fairport station at once entered upon such operations. But altho the feasibility of mussel culture has been amply demonstrated, many problems connected with it remain unsolved, and the investigators expect to continue their researches with especial reference to conditions of growth of the mussels, their food, enemies, diseases, and the very interesting question of pearl formation. ETHEL M. SMITH.

MINERAL RESOURCES.—*A reriew of the phosphate fields of Florida.* W. H. WAGGAMAN. Bulletin 76, Bureau of Soils.

The author describes the classes of Florida phosphate which are at present commercially important. These are the hard rock phosphate occurring along the west coast of the Florida peninsula and the land pebble phosphate which is mined to the south of the hard rock fieldsin Polk and Hillsboro Counties. The geological occurrence physical properties and their relation to the chemical composition of the rock are described, the methods of mining and preparing the rock for the market are described, and the cost of production and percentage of waste material are estimated. Possible means of utilizing this waste are suggested. The present output and conditions in these fields and the future outlook of the industry are discussed. W. H. W.

MINERAL RESOURCES.—*A report on the natural phosphates of Tennessee, Kentucky and Arkansas.* W. H. WAGGAMAN. Bulletin 81, Bureau of Soils.

The geological occurrence, physical properties and chemical composition of the different varieties of rock in the phosphate fields of Tennessee, Arkansas and Kentucky, are described together with the methods of mining and treating the material for the market. In Tennessee there are three types of phosphate which are commercially important, namely the brown rock of ordovicean age, the blue rock or devonian phosphate, and the white rock which has been laid down at a later period.

The former wasteful methods of mining in these fields are being rapidly supplanted by more modern and economical methods. Many of the old dumps and waste heaps are being worked over and valuable phosphate rock thus recovered. The cost of preparing the brown and blue rock for the market is approximately $2.50 per ton. The white rock is not being mined at present.

The deposits of phosphate in northern Arkansas are not generally regarded as of much economic importance but they are being worked to a considerable extent and are well situated to supply the demand for fertilizers west of the Mississippi. The rock is mined like the blue rock of Tennessee and belongs to the same Geologic period. The grade of the rock is lower but the average cost of mining it is probably not as great.

The phosphate deposits of Kentucky have not as yet been exploited. They occur in the blue grass regions near Lexington and are probably

of greater extent than they are popularly supposed to be. The rock is very much like the brown rock phosphate of Tennessee and belongs to the same geologic epoch. Some specimens of Kentucky phosphate show a very high content of phosphoric acid but the material will have to be washed and graded before it can be used for the manufacture of acid phosphate. W. H. W.

GEOLOGY.—*The Bonnifield region, Alaska.* STEPHEN R. CAPPS, Bulletin U. S. Geological Survey No. 501. 1912. Pp. 62, with maps, views, and sections.

The Bonnifield region lies on the north slope of the Alaska Range and is bordered on the east by Delta River and on the west by the Nenana, and includes both the rugged mountains of the main range and the foothills belt.

The northern part of the area is occupied by Birch Creek schist composed of highly-contorted and fissile mica and quartz schists and phyllites. The Totatlanika schist lying north of the Birch Creek schist in the western part of the region is characteristically a porphyritic schist or augen gneiss, with phenocrysts of feldspar and quartz in a fine-grained groundmass composed chiefly of mica and quartz derived from rhyolites or rhyolite porphyries, with perhaps some tuffs. Associated with these altered igneous rocks are carbonaceous shales, schists, limestones, and conglomerates of sedimentary origin. The Totatlanika schist is provisionally assigned to the Silurian or Devonian.

Eocene coal-bearing beds occupy warped basins in the schists and underlie more recent deposits in the lowlands.

The coal-bearing series is succeeded by the thick Nenana gravels. These in places are conformable with the coal series but in other localities there was a period of deformation and erosion between the two. The gravels are believed to be Tertiary.

The two schist series are cut by extensive bodies of intrusive rocks, chiefly granites and diorites, and the intrusive masses were important in causing the mineralization of the schists. Placer gold, derived originally from the schists, and scattered in small quantities through the Tertiary gravels has in places been reconcentrated into workable placers.

S. R. C.

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AGRICULTURE.—*Soil surveys* (Advance sheets—Field operations of the Bureau of Soils, 1909–1910) as follows:
Baldwin County, Ala. W. E. THARP, H. JENNINGS, and C S. WALDROP,

Department of Agriculture, and W. L. Lett, P. H. Avary, and L. Cantrell, Alabama Department of Agriculture and Industries. Pp. 74. Map.

Dale County, Ala. Lewis A. Hurst and R. W. Rowe, Department of Agriculture, and A. D. Cameron, Alabama Department of Agriculture and Industries. Pp. 39. Map.

Pike County, Ala. W. E. Tharp, Department of Agriculture, and W. L. Lett and W. E. Wilkinson, Alabama Department of Agriculture and Industries. Pp. 67. Map.

Livermore area, Cal. H. L. Westover and Cornelius Van Duyne. Pp. 64. Map.

Madera area, Cal. A. T. Strahorn, H. L. Westover, L. C. Holmes, E. C. Eckmann, J. W. Nelson, and Cornelius Van Duyne. Pp. 43. Map.

Marysville area, Cal. A. T. Strahorn, W. W. Mackie, H. L. Westover, L. C. Holmes, and Cornelius Van Duyne. Pp. 56. Map.

Jacksonville area, Fla. Grove B. Jones and James E. Ferguson. Pp. 26. Map.

Bulloch County, Ga. Charles N. Mooney, R. B. Hardison, David D. Long, and W. C. Byers. Pp. 52. Map.

Sumter County, Ga. J. C. Britton and F. S. Welsh. Pp. 47. Map.

Walker County, Ga. W. E. McLendon. Pp. 42. Map.

Rockcastle County, Ky. R. T. Avon Burke, Frank Bennett, and Clarence Lounsbury. Pp. 36. Map.

Concordia Parish, La. Charles J. Mann, E. B. Watson, Percy O. Wood, and Risden T. Allen. Pp. 35. Map.

Adams County, Miss. W. J. Geib, Department of Agriculture, and A. L. Goodman, Mississippi Geological Survey. Pp. 32. Map.

Noxubee County, Miss. Howard C. Smith and W. J. Geib, Department of Agriculture, and A. L. Goodman, E. M. Jones, and W. M. Spann, Mississippi Geological Survey. Pp. 46. Map.

Cooper County, Mo. A. T. Sweet, Department of Agriculture, and E. S. Vanatta and B. W. Tillman, University of Missouri. Pp. 37. Map.

Marion County, Mo. J. C. Britton, Department of Agriculture, and E. S. Vanatta, University of Missouri. Pp. 26. Map.

Fallon Area, Nevada. T. Strahorn and Cornelius Van Duyne. Pp. 44, 4 Pls. 2 Maps.

Cabarrus County, N. C. Risden T. Allen, Department of Agriculture, and E. W. Thornton and Hubert Hill, No. Carolina Department of Agriculture. Pp. 47. Map.

Granville County, N. C. R. B. Hardison and David D. Long. Pp. 44. Map.

Marshfield area, Oregon. C. W. Mann and James E. Ferguson. Pp. 38. Map.

Erie County, Pa. Gustavus B. Maynadier, Department of Agriculture, and Floyd S. Bucher, Penn. State College. Pp. 52. Map.

Washington County, Pa. F. S. Welsh and Floyd S. Bucher, Department of Agriculture, and D. K. Sloan, Penn. State College. Pp. 34. Map.

Central Gulf Coast area, Texas (Reconnoissance.) William T. Carter, Jr., and Party. Pp. 75. Pls. 8. Map.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE WASHINGTON ACADEMY OF SCIENCES

The 78th meeting of the Washington Academy of Sciences was devoted to an exhibit, 8–11 p.m., March 28, 1912, in the New National Museum, of new apparatus, methods, and results from various government bureaus and other scientific institutions of Washington. Over twenty bureaus and scientific institutions took part in the exhibit, and together rendered it one of the most instructive and enjoyable occasions the Academy has ever had. Over 600 persons, members of the Academy and their friends, attended this meeting, and everyone saw interesting apparatus and valuable results he had never even heard of before. Indeed this exhibit was so entirely successful that a similar exhibit probably will be given again in a year or two.

The 79th meeting was held jointly with the Philosophical Society, Saturday evening, May 4, 1912, at the Cosmos Club. Prof. DAYTON C. MILLER of the Case School of Applied Sciences, Cleveland, Ohio, gave an illustrated and experimental lecture on *Sound-waves; how to photograph them and what they mean.*

Both the synthesis and the analysis of sound-waves were shown and explained, and, to the delight of everyone present, many musical notes produced by tuning forks, by the flute, and by the speaker's voice, were made to trace upon the screen, as by a moving master hand, their wonderful curves of harmonic complexity.

It is not often that an audience finds itself really instructed on a difficult scientific question and at the same time so charmed and delighted as to wish the lecture twice as long, but this was one of those rare occasions.

W. J. HUMPHREYS, *Recording Secretary.*

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 708th meeting was held on April 6, 1912, Vice-President Burgess in the chair. One paper was presented:

Evolution of the aeroplane; its fundamental features of English origin: A. F. ZAHM.

Two informal papers were presented, one on *Earth light* and one on *Holes in the air,* each by W. J. HUMPHREYS, of the U. S. Weather Bureau.

709th meeting, April 20, 1912, Vice-President Burgess in the chair. One paper was presented.

Account of researches in the algebra of physics: ALEXANDER MACFARLANE.

170th meeting, May 4, 1912, was a joint meeting with the Washington Academy of Sciences, and at which Prof. DAYTON C. MILLER of the Case School of Applied Science spoke on *Sound waves; how to photograph them and what they mean.*

711th meeting, May 18, 1912, Vice-President Fischer in the chair. Two papers were read:

Some problems in wireless telegraphy: F. A. KOLSTER, of the Bureau of Standards.

Present flame standards of candle power: E. C. CRITTENDEN, of the Bureau of Standards.

R. L. FARIS, *Secretary.*